EXPLORING THE GOAL OF ENVIRONMENTAL EDUCATION:

Using Earth Systems Education to Encourage Environmental Literacy

Presented in Partial Fulfillment of the Requirements for the Honors Program of the School of Natural Resources, The Ohio State University

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BACKGROUND

As I searched for a "topic" for this honors project, I kept in mind my overall goal: to synthesize what I have learned and experienced through environmental communications, education, and interpretation (ECEI) while exploring further a topic of interest. Natural Resources 810, a course I completed in the autumn with Dr. Rosanne Fortner, interested me in the research and debate surrounding the goals of environmental education and it was in this class that I was exposed to the concept of "environmental literacy".

I also wish to share my experience as an undergraduate in the School of Natural Resources as I have had the opportunity to develop my own environmental literacy through Earth Systems Education. Participating in the 1996 Dominican Republic study abroad program gave me the opportunity to use my interest and knowledge of environmental education to introduce these concepts in a new setting and I wanted to carry this hands-on learning and exploring into this project. I wanted to utilize this last quarter to integrate what I have experienced with research into the ideology of environmental education.

What I have found has been intriguing, thought-provoking, and a bit frustrating. I talked with new natural resources professionals, having recently graduated from the School of Natural Resources, who offered suggestions and their own interpretation of environmental literacy. I interviewed my peers, experiencing the same pre-graduation stress as I, to find out if they felt prepared to help others to become environmentally literate. The many perspectives of what environmental education means, how literacy is defined, and the role it should play in our educational system were the focuses of this study. I struggled with the lack of agreement among professionals and questioned my own understanding of what environmental education encompasses.

As I developed a problem statement, it extended and branched into the following five "investigative statements":

1. Although the *Benchmarks On The Way To Environmental Literacy* (1995 draft) define the ultimate goal of environmental education as "to develop an environmentally literate citizenry" there is still considerable debate as to the ideology behind the terminology.

2. As the national and state standards prepare K-12 students to achieve a degree of environmental literacy, institutions of higher education need to embark on the integration of environmental literacy into the curriculum.

3. There is a need to prepare ECEI students not only to be environmentally literate themselves but to guide others as well.

4. Earth Systems Education (ESE) provides opportunities for students to experience innovative teaching methods that will be useful in their careers. ESE may serve as a unifying element in the natural resources curriculum.

5. My experience integrating ESE courses with the ECEI curriculum has enabled me to become more environmentally literate and feel confident about conveying the concepts to others.

The first two statements evolved from questions I had while studying *Benchmarks On The Way To Environmental Literacy* (1995 draft), which serve as starting point for the development of national standards in environmental education. A summary of the ideology behind the development of these benchmarks can be found in Appendix A. I began to realize that I really had no firm conceptual understanding of what environmental education encompasses. In order to explore the historical evolution of this term and to take a closer look at some of the debate surrounding this issue, I conducted a literature review, hoping to find some answers. I discovered many answers and even more questions, presented in Sections Two and Three of this paper.

When I was first exposed to an in-depth definition of environmental literacy in Natural Resources 810, I questioned my own level as a natural resources major and supposedly informed citizen. I was surprised to find that it was not only my understanding of concepts and processes but my attitudes and behavior that would determine my level of environmental literacy. I wondered if my peers and I could be considered environmentally literate and whether that should be a requirement of all natural resources graduates as well as all graduates of the university. While I could not conduct an extensive survey of students to assess their competence and level of environmental literacy at this time, I informally interviewed my peers, both graduating seniors and those that have recently graduated from the ECEI major. To investigate statement three, I asked if they considered themselves to be environmentally literate and if they felt prepared to guide others towards environmental literacy.

I have been involved in Earth Systems Education through my work with Dr. Rosanne Fortner and Dr. Victor Mayer and by incorporating classes taught using ESE methods into my curriculum. I believe that ESE could be integrated in the School of Natural Resources not only to unify the curriculum but encourage environmental literacy of its graduates as well.

The completion and presentation of this project will illustrate the investigation of the final statement. It is this "thesis statement" that I will continue to explore and expand on throughout my experience as a natural resources professional.

II. ENVIRONMENTAL LITERACY AS THE GOAL OF ENVIRONMENTAL EDUCATION

What is the goal of environmental education?

According to the *Benchmarks On The Way To Environmental Literacy* (1995 draft) (referred as *Benchmarks* here after), the ultimate goal of environmental education is "to develop an environmentally literate citizenry." However, this definition has been evolving since the 1960s with scholarly debate surrounding the educator's role in encouraging environmentally responsible behavior. Whether environmental education should be developed as its own discipline or infused into already established subjects is also an issue of disagreement.

In 1969, William Stapp introduced the goal of environmental education by stating:

> *Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solutions" (Stapp 1969).*

This definition helped to guide the Tbilisi Conference in 1977 where the guiding principles of environmental education, including environmental literacy, were adopted by delegates from 66 nations. UNESCO published a paper later that year that stated that "improvement of the lot of humanity" was the ultimate goal and that environmental education must "instill a sense of importance as agents of change who must seek evidence, think critically, and challenge the ways things always have been done" (UNESCO 1977). Research conducted at this time also began emphasizing the development of action skills in students as an objective of environmental education (Hungerford and Tomera 1977).

Throughout the 1980s, researchers continued to define the goals of environmental education (EE). Four elements, or strands, of EE came to be recognized: knowledge, skills, attitudes, and behavior (Roth 1992). Models to evaluate "responsible environmental behavior" were created and used to measure the success of environmental education programs (Volk, et al. 1984). The term "environmental literacy", first introduced by Charles Roth in 1968, began to be widely associated as the ultimate goal of EE, although used in different contexts.

Whether it be an argument of semantics, ideology, or both, these definitions have been challenged by another faction of researchers. Ian Robottom has argued that teaching responsible environmental behavior has certain ramifications, such as the ethical implications of teaching viewpoints and suggesting opinions and actions (Robottom 1987, 1995). Peter West points out that conservative research groups are questioning the ideological approach to environmental education, citing that the goals and methods are developed as indoctrination rather than education (West, 1993). Many researchers have stressed the importance of skill building and awareness through introduction of concepts and processes without advocating environmental solutions (Jickling 1990, Robottom 1995, Weilbacher 1994). It has also been argued that many goals of environmental education, such as responsible behavior, citizenship, and problem solving skills, reflect training not education (Jickling 1990).

In 1990, the National Environmental Education Act (Public Law 101-619) was passed to create federal involvement and support of EE. This act showed a renewed interest in coordinating programs and environmental education goals nationally. However, in Section 3 of the Act, Congress took a very broad approach to defining environmental education (Marcinkowski 1992). While there was federal support for the development of national standards, the lack of agreement on the goals of environmental education prohibited the development. The Environmental Education Task Force of the American Society of Testing and Materials began in 1989 to establish a consensus of environmental education standards. The existing curricula were also evaluated at this time to determine where environmental education was heading. Studies conducted in the late 1980s showed that "environmental education is effective in producing environmental values but only if programs and methods designed specifically to accomplish those objectives are used (Iozzi 1989). Volk and Hungerford's work repeatedly showed that the goals of EE were not being met by existing curricula and that a need existed for both goal-oriented curriculum development at all age levels as well as teacher education (Volk, et al. 1984, Hungerford, et al. 1981).

Environmental literacy is often associated with and mistaken for science literacy. Research has demonstrated a perception that integrating environmental topics into the curriculum is "moderately difficult" and that attention given to environmental issues is mainly achieved in science classes (Disinger 1989, Fortner 1991, Iozzi 1989, Simmons 1989). As the science curriculum has been restructured and proficiency tests implemented, there is little room to fit in environmental education (Fortner 1991). This furthers the need for *Benchmarks* that will serve as a guide not only in science classrooms but social studies, art, music, health, and others as well.

Iozzi's suggestion that the "development of environmental attitudes and values should begin as early as kindergarten age and be further developed and continually reinforced throughout the entire learning process" was continually reinforced by education research (Iozzi 1989, Roth 1992). Therefore, *Benchmarks* needed to tailor goals and objectives to all age levels.

The goal of environmental education is explicitly stated in *Benchmarks* as follows:

> *...to develop an environmentally literate citizenry, thus environmental education focuses on empowering individuals to deal effectively with positive and negative relationships between people and environments.*

This definition includes the four elements or strands of EE: knowledge, attitudes, skills, and behavior, but it is doubtful that they serve as representative of EE professionals' views given the history of debate surrounding this terminology.

What is environmental literacy?

Charles Roth, who is serving as the editor for the national environmental education standards, first introduced the term "environmental literacy" in 1968. In his 1992 monograph, *Environmental Literacy: Its Roots, Evolution and Direction in the 1990s,* he states that environmental literacy is:

> *...essentially the degree of our capacity to perceive and interpret the relative health of environmental systems and to take appropriate action to maintain, restore, or improve the health of those systems.*

The goal of environmental literacy is further described as:

> *...an environmentally literate citizenry that is properly informed, properly sensitive to environmental concerns at all levels, and empowered to take responsible action to assure a healthy environment for the present and the future.*

In order to measure or assess environmental literacy, it can be operationalized as a continuum with three major levels: nominal, operational, and functional, summarized in Figure One. Nominally literate people recognize many of the basic terms and definitions of terms commonly associated with the environment and are developing sensitivity and respect for the natural environment. Those at the functionally environmentally literate level have a broader knowledge and understanding, have developed awareness and sensitivity, have the skills to analyze, synthesize, and evaluate information, and demonstrate motivation to work towards solutions to problems they find of interest. Operational environmental literacy indicates that the person not only "routinely evaluates the impacts and consequences of actions" but advocates action positions and demonstrates "a strong, ongoing sense of investment in and responsibility for preventing or remediating environmental degradation both personally and collectively" (Roth 1992).

Environmental literacy differs from science literacy as it is based on a Ecological Paradigm rather than a mechanistic one. The basic issues of environmental education, interrelationships between natural and social systems, unity of humankind with nature, technology and the making of choices, and developmental learning throughout the life cycle, represent the interdisciplinary nature of EE and distinguish it from a "fact and figure" discipline. Instead of being knowledgeable about a particular subject, students' observable *behaviors* determine the degree of their level of environmental literacy (Roth 1992) (emphasis added).

There has been little research conducted on the assessment of environmental literacy. Now that term has been more precisely defined by *Benchmarks,* assessment instruments may be developed. The development of an environmental literacy framework will allow researchers to legitimately assess "citizens' capacity to be active participants in environmental restoration and maintenance" (Marcinkowski and Rehrig 1995). Four outcomes are considered: cognitive learning development, affective outcomes, determinants of responsible environmental behavior, and personal involvement in environmental issues and solutions.

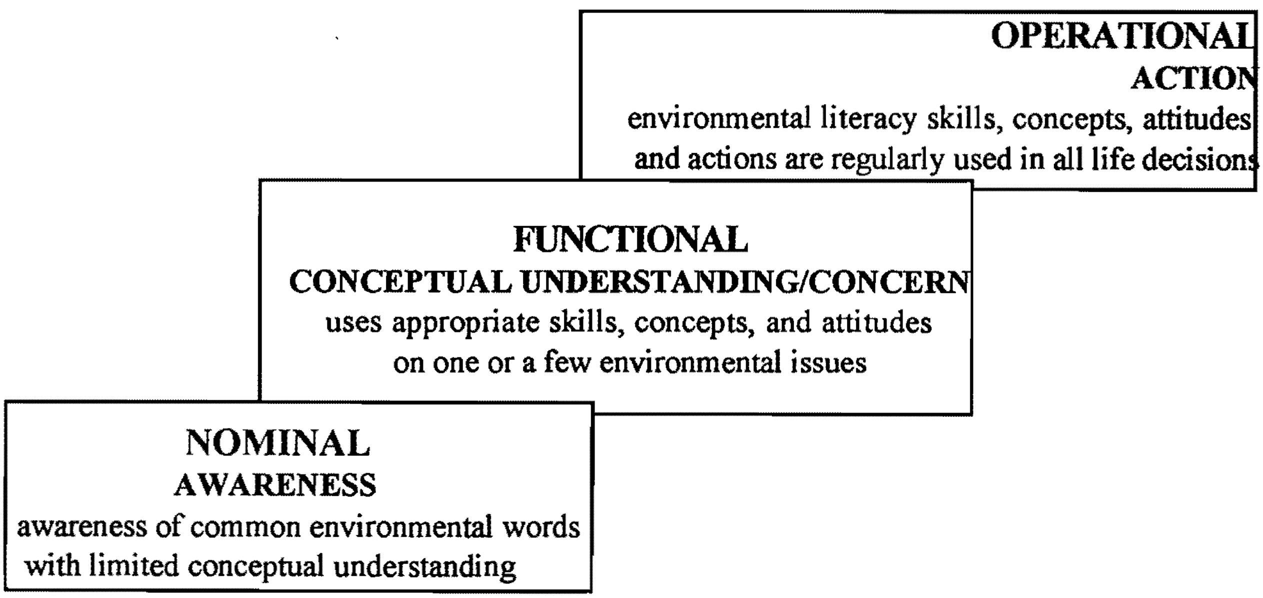

Figure 1. Environmental Literacy Continuum (Roth 1992).

III. ENVIRONMENTAL LITERACY IN HIGHER EDUCATION

How is environmental education presented in higher education settings?

> *"The kind of discipline-centric education that enabled us to industrialize the Earth will not necessarily help us heal the damage caused by 150 years of industrialization. Despite all clear evidence of spreading environmental problems, this message has not made much headway in the vast majority of colleges and universities" (Orr 1995).*

The majority of research and debate over the ultimate goals of environmental education center around K-12 curriculum development. However, as Orr points out, little attention is given to these issues in colleges and universities. Because curriculum and research are fragmented into disciplines and departments, a narrowed intellectual focus and the encouragement to conform to set standards results. Orr argues that publication and research have become more valued than teaching, illustrating a lack of "integrity and ingenuity" on the part of the educators (Orr 1995).

Because environmental education involves information and cooperation from many disciplines, it has not been able to flourish in many college/university environments based on disciplinary strength. For example, although an environmental issue may arise in a social science classroom, this discipline alone does not give students the proper tools to evaluate contradictory claims. Supplemental knowledge of the sciences is often necessary. Environmental education in the college classroom, therefore, should focus on environmental attitudes, behaviors, and values, the environmental movement, risk perception, and the political economy of the environment (Cylke 1995).

Recently, some institutions of higher education have developed programs to encourage the environmental literacy of its graduates. In 1990, faculty from Pennsylvania State System of Higher Education, Kent State University, and the Ohio Department of Education participated in a workshop to address their role and responsibilities in nurturing environmental literacy within their student bodies. This includes encouraging exploration of issues, consequences, and reasoning and problem solving skills (Wilke 1995). Tufts University has established the Tufts Environmental Literacy Institute to assist faculty in providing "broad, continuing and repetitive exposure to environmental issues throughout the educational experience..." (Cortese 1990).

Integrating environmental themes into the already crowded curriculum is often met with frustration and trepidation from faculty. Even though *Benchmarks* strive towards the environmental literacy of all K-12 students, environmental literacy of all graduates is not an accepted goal throughout all colleges and universities. Perhaps this reaction results from the ambiguity of the definitions of environmental education and environmental literacy. Focusing on thinking processes rather than facts, problem solving exercises that cut across specializations, and guided discovery can be done throughout all disciplines to help create and augment all students' level of environmental literacy. Richard Wilke has written on suggested state legislation for many issues, recommending the following model environmental legislation to help solve this problem:

> *Universities, colleges, and vocational institutions are required to implement programs that encourage environmental literacy and provide support for environmental stewardship among the student population (Wilke 1994).*

How does Earth Systems Education encourage environmental literacy at any grade level?

The Earth Systems Education (ESE) effort, centered at The Ohio State University and The University of Northern Colorado, attempts a "more comprehensive understanding of the nature of science and its intellectual processes including the historical descriptive approaches commonly used by the earth and biological sciences" (Mayer et al 1992). It is a way of organizing the curriculum to meet the national standards not only in science education but environmental education as well (Mayer and Fortner, eds. 1995). It seeks to augment the curriculum in three ways:

1. philosophically - how we think of ourselves and our place in the universe
2. methodologically - intellectual methods that we use to investigate our surroundings

3. conceptually - what we know about our world and how it functions

An ESE curriculum can be structured around four main themes, all of which guide learners towards environmental literacy. The ***content*** of the curriculum is based on a framework of Seven Earth Systems Understandings (Fig. 2), broad statements that every learner at every level should explore and operationalize individually. These understandings include emphasis on appreciation and stewardship of the Earth and embody what all students should know about the Earth, regardless of the subject of study (Mayer and Fortner, eds. 1995). Appendix B provides an extended Framework that expands on each Understanding.

EARTH SYSTEMS UNDERSTANDINGS	
Understanding #1.	Earth is unique, a planet of rare beauty and great value.
Understanding #2.	Human activities, collective and individual, conscious and inadvertent, affect Earth Systems.
Understanding #3.	The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.
Understanding #4.	The Earth system is composed of the interacting subsystems of water, land, ice, air, and life.
Understanding #5.	Planet Earth is more than 4 billion years old and its subsystems are continually evolving.
Understanding #6.	Earth is a small subsystem of a solar system within the vast and ancient universe.
Understanding #7.	There are many people with careers that involve study of Earth's origins, processes, and evolution.

Figure 2. Framework for Earth Systems Education (Mayer et al 1992)

The curriculum must be ***structured and organized*** with an interdisciplinary approach among not only the sciences but the social sciences, language arts, and art and music. With an ***organizing principle of the Earth***, the curriculum should also encourage students to explore and use technology to understand the Earth as a unifying element in their studies. The final theme is the encouragement of ***cooperative learning climates*** which allow learners to interact through peer teaching. This also involves the use of authentic assessment, procedures that allow students to demonstrate their understanding with "real world" projects (Mayer and Fortner, eds. 1995).

ESE places less emphasis on the traditional experimental approach and encourages the use of the historical method and analysis of data to arrive at hypotheses and conclusions. Combining humanities, science, and technology allows the student to take an interdisciplinary approach to problem solving. Collaborative learning techniques encourage interactions common among decision makers in the "real world" (Fortner 1991).

The concepts of Earth Systems Education can be used at any level of study in any discipline to integrate environmental education into the curriculum. The Earth Systems Understandings alone exemplify the four strands necessary to achieve environmental literacy: knowledge (all), attitudes (#1,2), skills (#3,7), and behavior (#1,2,7).

IV. THE PRACTICALITY OF ENVIRONMENTAL LITERACY: A Closer Look at ECEI graduates

How can knowledge of environmental literacy be assessed?

The *Philosophy for Undergraduate Education in Natural Resources* (1987) does not mention the term "environmental literacy." As the *Benchmarks* require curriculum restructure at the K-12 levels, students should have attained a level of environmental literacy prior to entering the university. Therefore, they should continue to be encouraged to augment their environmental literacy through higher education, especially in the School of Natural Resources. ECEI majors must not only be environmentally literate themselves but must have an understanding of what environmental literacy encompasses and how to encourage it in others. Especially as environmental education professionals are developing activities and programs to concur with the national standards should the environmental literacy standard be understood. As the School of Natural Resources and The Ohio State University prepare to overhaul the curriculum, environmental literacy should be the ultimate goal.

In order to assess the level of environmental literacy of the chosen population, an extensive surveying procedure would have to be established. Perhaps as the Environmental Literacy Assessment Instrument is developed for secondary schools, it can also be used at the university level (Marcinkowski and Rehrig 1995). Smith-Sebasto has developed an instrument that assesses the relationship between locus of control of reinforcement and environmentally responsible behavior in university undergraduate students. This could be administered to natural resources students upon entering and graduation from the program to assess the effectiveness of the curriculum to encourage environmental literacy (Smith-Sebasto 1992). For the purposes of this project, informal interviews were conducted to collect general impressions of both the concept of environmental literacy and the effectiveness of the ECEI major requirements.

An informal survey of a select group of graduating seniors and recent graduates of the

ECEI program offered some idea of the general understanding of the concept of environmental literacy and the level of preparedness to teach others to be environmentally literate. The six people who were interviewed were given names of things associated with Autumn for the purpose of anonymously reporting their comments. Three graduates from the ECEI program in the last year and currently employed as environmental educators were selected. Turkey and Cider hold positions in informal education while Indian Corn teaches in a formal setting. Three undergraduates, Pumpkin, Squash and Gourd, were selected based on convenience of obtaining an interview. Squash also has participated in an ESE oriented class and was chosen to find whether this particular class affected his understanding of environmental literacy and his preparedness in conveying these concepts to others. These six subjects all were personally interviewed face to face and all were asked the same set of questions. A sample questionnaire can be found in Appendix C. A discussion group of 11 ECEI students of all ranks informally commented on these questions as well as a result of a class meeting in Natural Resources 613, Spring Quarter 1996. The group discussed the concept of environmental literacy and whether or not they felt prepared to be effective environmental educators. These comments were taken into account in the following conclusions.

Do ECEI majors feel prepared to guide others towards environmental literacy?

Environmental literacy is understood by many students and graduates as knowledge or understanding of common environmental terms and issues. The idea that literacy is assessed by observable behaviors took many by surprise. When given the definition on environmental literacy as stated in *Benchmarks*, everyone interviewed responded that they did not feel prepared to guide others towards environmental literacy according to this definition. ECEI majors find that they can convey ideas and concepts but lack the skills to encourage behavior changes. Specific comments on environmental literacy follow:

"I am a teacher in a small town and there is no way I could get away with encouraging action in my students. The community would not go for a class picketing a local business. I realize this is an extreme example of environmentally responsible behavior but I have to be really careful. I feel much more comfortable giving my students the facts and skills to act responsibly than telling them what to do" (Indian Corn).

"I think that the word "behavior" needs to be put into context. I don't think they mean that you should lead people on a sit-in or force people to take a certain action. As an educator, I hope that the subject matter I teach will encourage people to be environmentally conscious. I will have to watch how much I spout off my personal beliefs" (Pumpkin).

An overwhelming concern expressed by the majority of the students was that while they felt prepared to educate, communicate, and interpret, the actual subject matter to be conveyed was not well understood. The need to rely on outside experiences and the skills to learn the names and functions of "things" was emphasized. Specific comments made were:

"I would not have landed my current position if I had not taken the time to learn the local flora and fauna in depth. The classes required of an environmental education major did not give me the background necessary to be an *environmental* educator (emphasis added). Advisors should encourage all students to take an ornithology class, for example" (Cider).

"I realize that the program cannot possibly encompass all aspects of every ecosystem. However, the basic ecological principles need to be continually reinforced throughout our curriculum and I do not not feel that this happens right now" (Turkey).

"I am a little overwhelmed about getting a job in our field. I just don't feel like I know anything about nature" (Gourd).

"We cannot learn everything there is to know in the School of Natural Resources. I definitely believe that everyone should be encouraged to take a general ornithology and dendrology class so that when you get to the area that you are going to be working in, you have the basic knowledge and can go out and find more out about the ecosystem" (Squash).

A common issue among those interviewed was the method of teaching science at the university level. "Science classes are not integrated and the question 'So what?' is often left unanswered" (Turkey). Some students felt that the required science courses relied too much on theory and not enough on the real world applications that would be beneficial for them to explore (Pumpkin, Squash, Gourd, Indian Corn).

The National Science Education Standards have echoed this concern by stating that "because of the crucial role of science courses, reform in the content and teaching of undergraduate science is imperative" (Standards 1996). The Standards suggest a science curriculum that focuses on investigations, opportunities to gather and interpret data using appropriate technologies, and to work on real world problems. Learning through inquiry is also stressed.

Only one student participated in a course using ESE principles and expressed concern that "the methods of teaching and the portfolio elements worked well for me but I really don't think all learners would respond in the same way. I have a hard time believing that professors would use these methods in a large lecture class. It would take a lot of time and a lot of them are set in their own ways" (Squash).

As a result of these interviews of a select group of students and graduates, several conclusions can be drawn:

1. ECEI majors do not feel that the curriculum is unified and integrated with the courses they take outside the School of Natural Resources.

2. While ECEI majors feel that the required courses adequately prepare them to educate,

the actual subject matter to convey is lacking.

3. ECEI majors define environmental literacy as the understanding of environmental terms and issues and do not recognize the behavioral component.

Are these concerns valid?

While many of the comments recorded in the previous section may seem negative, it is interesting compare the answers. For example, the majority of those interviewed said that they felt prepared to communicate facts although many of the same people are concerned about their own level of knowledge. While several people felt that their education was lacking in the area of natural history and ecology, the idea that education should provide the necessary skills to find information and answers was also emphasized (Turkey, Pumpkin, Gourd). Concern #2 is valid although students seem to need a reminder that their education cannot possibly provide them with in depth study of all ecosystems and that is partly their responsibility to learn about specific areas on their own. The development of critical thinking and problem solving skills are imperative for students to be able to continue this learning beyond their formal education.

Lack of integration of the natural resources curriculum with other university requirements as well as within the School was a concern voiced by the majority of those interviewed. This issue as well as the comments made about the use of ESE in the natural resources curriculum will be addressed in Section Five.

V. Earth Systems Education and the Natural Resources Curriculum

How are the principles of ESE already implemented in the university curriculum?

The natural resource curriculum encourages students to take an interdisciplinary approach to their education by taking courses throughout many departments in the university. Efforts at Earth Systems Education are already being undertaken within other areas of the university. For example, The Ohio State University participates in the University-based Cooperative Program in Earth Systems Science Education linking together faculty and scientists in the field to train new scientists with an interdisciplinary approach. Each institution offers two courses: a survey course that introduces the student to different aspects and implications of global change and a senior level course that requires the use of problem solving skills in a project oriented environment. Twenty-two institutions are currently participating in this program including The Ohio State University under the direction of Dr. Ellen Mosley-Thompson (Kalb 1993).

Earth Systems Science at The Ohio State University is being developed as a series of courses in geology, geography, and at the capstone level that attempt to integrate the sciences with an Earth Systems focus. The Department of Geological Sciences offers a series of courses focusing on the Earth System. Earth Systems I: The Geological Environment (Geology 100) leads students to investigate all subsystems, includes study of all Seven Earth Systems Understandings, and focuses on the issue of global change to give students a real world perspective. Earth Systems II: The Atmosphere (Geography 120) focuses on the interactions between all subsystems with the atmosphere and includes practical discussions and exercises. Geology and the Environment (Geology 203) explores environmental issues from a geological viewpoint. These three courses form the basic curriculum in the Department of Geology (McKenzie 1995).

Capstone courses offered throughout the university are designed to focus on human issues. Integrated Earth Systems: Confronting Global Change (Geography 597.02) uses the issue of global climate change to involve students in real world problem solving using the latest technology available. Population and Resources in the Earth System (Political Science/Biology 597.02) also uses current environmental issues to encourage students to explore the human dimension (McKenzie 1995). Antarctic Marine Ecology and Policy (Natural Resources/Zoology 597.02) is currently undergoing restructuring to include the principles of Earth Systems Education. This will allow students to develop critical thinking and decision-making skills necessary for professional leaders (Berkman 1996).

How can ESE be used to integrate the natural resources curriculum?

Presently, there is no overarching theme in the natural resources curriculum that ties together courses and experiences. Earth Systems Education could be integrated into the current curriculum without changing or adding course requirements.

The content of ESE, based on the Seven Earth Systems Understandings, could be used as a basis for all natural resources classes. After all, many students have or are seeking "careers and interests that involve study of the Earth's origin, processes, and evolution" (ESU #7). The School of Natural Resources has the opportunity to integrate the many subjects the student is exposed to with the unifying principle of the Earth. The management aspect that is now emphasized in many natural resources courses should focus on integration of the "hard" and "soft" sciences and incorporate the development of problem solving and decision making skills into the requirements. The ESUs could be introduced in the introductory classes and referred to throughout the School's course offerings. The capstone level course should focus on these themes and give students the opportunity to operationalize them according to personal interests and goals.

Cooperative learning is already integrated into some natural resources courses and should continue to be used throughout the curriculum. Specific to the ECEI major, Natural Resources 615, has included cooperative learning and the use of authentic assessments recently and student evaluations have been positive (Fortner 1996). Peer teaching is also encouraged in Natural Resources 613 allowing the students to practice their skills in environmental education.This allows students the opportunity to learn from each other through creative guided discovery rather than the traditional lecture setting. This is difficult in the larger classes but can still be done through the development and presentation of group projects. Because natural resource professionals need to interact with people and remain aware of new developments and issues, cooperative learning is one way of practicing these skills.

Authentic assessment could also be incorporated into the curriculum by individual instructors. The traditional term paper needs to be replaced with real world projects throughout a student's education. While several courses already implement these kind of projects, instructors should continue to be encouraged to provide these opportunities for students.

Currently, there are several course offerings that are based on the principles of Earth Systems Education. Great Lakes Education Workshop (Natural Resources 611), Aquatic and Marine Education (Natural Resources 614), and Global Change Education (Natural Resources 690/797) are usually offered in conjunction with the College of Education. These courses focus on the concepts presented in the Seven Earth Systems Understandings and use collaborative learning techniques and authentic assessments. An example of such a course is presented in Appendix D which includes a course syllabus showing the pathway of exploring the Earth Systems, a typical portfolio assignment and accompanying scoring rubric, and an sample portfolio element. This illustrates the kind of opportunities a student can have to explore a real world problem and create a project that may be useful after the actual assignment is over.

Currently, much of the natural resources core curriculum is taught by the lecture/recitation format. This is necessary most of the time due to the large number of students currently enrolled in natural resources. However, the principles of Earth Systems Education could be subtlety woven into the already existing course material in several ways. For example, the introductory course required of all natural resources majors, Environmental Science and Management (Natural Resources 100), includes lectures and discussions of all Earth systems. See Appendix E for the most recent syllabus. By introducing the Earth Systems Understandings at the beginning of the quarter, the class would be given the tools needed to organize and integrate the course materials. The course also requires 10 quizzes over reading and discussion material. Authentic assessments could be assigned in place of a few of these quizzes to give students the opportunity to explore further one of the many issues presented in class. This is an excellent opportunity to introduce students to the new technologies available on campus by encouraging them to find the most recent news of an issue on the Internet. Students may also report their findings in small groups to give them a chance to interact with their peers as well as practice a form of cooperative learning.

The capstone course required of all natural resources majors, Natural Resources Management (Natural Resources 606), serves to offer students of different majors an opportunity to work on a management issue in groups. A copy of the current syllabus can be found in Appendix F. Unfortunately, many students experience frustration in this course as many feel that they are not pulling together their combined knowledge and experience in the most beneficial and useful way. While the exercises in real world management may be well intentioned, the course seems to fall short in meeting some of its goals. The capstone course could be redesigned to again emphasize the Earth Systems Understandings in new and different ways. Students could still work on real world issues but may have more leniency in the development of a project. This course should provide the opportunity to synthesize knowledge and experience as well as develop problem solving, critical thinking, and analytical skills. There is a need to integrate natural resources courses and attention to this at the capstone level may help alleviate this.

The School of Natural Resources should not only teach students about the specifics of "natural resources" but strive to encourage students to integrate all disciplines. By continually emphasizing the Seven Understandings and encouraging students to learn from each other and through exploration of real world applications, the program would give students direction and assist them in achieving the primary objective of the School: "to integrate knowledge from many disciplines to address issues concerning natural resources effectively" (Philosophy 1987).

VI. CONCLUSIONS and RECOMMENDATIONS

My experience as an undergraduate ECEI major has been very rewarding not only because of the required courses but the electives I chose. I have taken two courses based on the concepts of Earth Systems Education, Marine and Aquatic Education and Global Change Education, and believe strongly that the concepts I learned, every natural resource major should experience. Not only was the content helpful in integrating what I learned from disciplines all across campus but the teaching strategies employed benefited me.

As the curriculum again undergoes revision, the concept of environmental literacy should become a focus for natural resources education as well as throughout the university. By encouraging the adoption of Earth Systems Education principles, the School of Natural Resources would not only provide a more integrated curriculum but would move towards the assuring of environmental literacy of its graduates. However, faculty often do not have the time or the resources to overhaul their course content or schedule. Several things could be done to help.

Distribution of Earth Systems Education materials through a faculty inservice would provide the necessary introduction to the basic concepts espoused by this program. Special attention at the introductory and capstone courses could be provided by the academic affairs committee when deciding on course requirements. Natural Resources 606 already needs to undergo revision as the number of students needing to take it increases every quarter. However, attention and the distribution of information will not insure infusion of ESE into the curriculum.

Perhaps graduate teaching assistants could provide the opportunity for restructuring. After all, it is they who usually lead the smaller recitation sections where cooperative learning techniques would more easily be used. The discussions that already take place in recitations of Natural Resources 367 and 400 could easily take place in a cooperative learning format. Often, it is these TAs who are responsible for the majority of the grading in these courses. Therefore, the use of authentic assessment should serve not only to allow the student to explore real world applications of course material but to cut down on the amount of grading. At the very least, the assignments should allow the graders to see how the students are incorporating the knowledge with their own ideas and experiences. Alternate grading procedures, such the use of a rubric, also could be implemented by the TAs.

The students that I interviewed expressed a need for integration of the natural resources curriculum. Instead of relying on other areas of the university to fill the gaps in the curriculum, courses within the School should pull together the disciplines to help students integrate what they have learned and experienced to allow them to be more effective decision makers and professional leaders.

The concerns specific to the ECEI major also need to be addressed. Students need to be reminded that it is not the purpose of their major to teach them everything there is to know about every ecosystem and natural feature. Academic advisors should continue to encourage students to participate in specific courses as part of their electives that will give them additional background in subjects of interest.

The students of tomorrow are going to be prepared prior to entering the School of Natural Resources according to the National Standards in several subjects. If the ultimate goal of environmental education in the K-12 curriculum is to develop environmental literacy, the new curriculum of the School of Natural Resources should encourage the broadening and increasing each student's level of environmental literacy. Not only should the School use this as a focus but should serve as a model for the rest of the university. Environmental literacy of all graduates of The Ohio State University should be encouraged and the School of Natural Resources can lead the way.

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APPENDIX A

Benchmarks On the Way to Environmental Literacy **summary**

THE BENCHMARKS FOR ENVIRONMENTAL LITERACY

The purpose of this document is to establish some benchmarks knowledge and understandings that can be achieved in schools in the K-12 range by the end of each of the three four-grade spans indicated. The concepts and skills presented can be infused throughout the various disciplines and courses covered in each four-grade span. They are **NOT** intended to be a separate course of study. However, it is expected that by the end of each span, students will have a working grasp of the ideas and skills presented. Each school system can work out sequencing of the material and points of infusion suitable to its own courses of instruction. **Benchmarks are simply statements of knowledge and skills that it is reasonable to believe educated individuals will possess by the grade levels suggested.** They are statements that can be used in assessing individual progress in developing environmental literacy.

In each grade range the benchmark statements fall into three categories chosen to communicate the important basic components of environmental literacy. These broad categories are further divided into subsets for ease of reference.

Ecological Knowledge: used here in its broadest sense of interconnectedness of information and involves science, geographic, historical and economic information.

- Bio-physical understandings
- Societal/ cultural/technological understandings
- Systems interactions

Skills: encompass physical manipulation skills, critical and creative thinking skills, communication skills, and political skills.

- critical and creative thinking skills
- investigative skills
- evaluation skills
- decision-making skills
- planning and organizing skills
- communication skills
- cooperation skills
- lifestyle and environmental management skills

Habits of mind : patterns of thinking that are routinely applied to dealing with problems.

- scientific habits of mind
- empathetic habits of mind
- self-empowerment

These benchmarks are **not** a curriculum. They are a set of goals and objectives to strive for in the growth and development of our citizens. They may be used by teachers, school administrators, and parents to guide the development of curriculum across a number of disciplines or as part of integrated curriculum development. They form a set of **guidelines to help bring about a citizenry that is truly environmentally literate and capable of living fruitful, responsible lives today while assuring a healthy environment for those who will follow.**

Sequencing

There is a broad developmental sequence

implicit in the grade level clustering of benchmarks.

The **K-4** grouping focuses on environmental awareness and the development of positive attitudes toward the world of nature and human society. Learners focus on basic concepts about the structure of the environment and its role in their lives.

The **5-8** grouping focuses on understanding the interactive processes between people and the environment. Learners explore their relationships with the world around them. They discover options and limitations and how to deal with each. Learners develop tools for recognizing and addressing environmental issues and explore the basic citizenship skills needed for taking individual and collective action to maintain, restore, or improve environmental conditions.

The **9-12** grouping focuses on developing depth of understanding about the ecological relationships between human activity and the environment and in honing the skills needed to make decisions and take actions to maintain, restore, or improve environmental conditions.
In terms of Massachusetts testing procedures, it is assumed that much of the knowledge component will be in place by the end of **grade 11** and that opportunities to put the knowledge to practice through case study explorations and community action projects will be provided during grades 11 and 12.

Using Environmental Literacy Benchmarks In Curriculum Development

The Role of Environmental Literacy Benchmarks

The environmental literacy benchmarks are not a curriculum in environmental education. They are a set of activities and abilities that can be accomplished effectively only if learners have acquired and can use sets of information, skills, and attitudes. Acquisition of the knowledge, skills, and attitudes may come from a variety of sources—school, home, community, media, interest groups, churches, and the like.

Schools and Environmental Literacy

It is assumed that a primary source of the development of environmental literacy will be the schools, particularly in terms of knowledge and skills. Schools are the places where the most organized presentation of information and skill development occurs. There are, however, a number of different ways of presenting the information.

Curricular Alternatives

Some schools will choose to present this as a distinct course with the primary objective of increasing understanding of how the natural world functions and may create courses titled something like "environmental science." Other schools will see that environmental literacy has components from a broad spectrum of traditional courses and will try to assure that appropriate concepts are developed within such courses as history, geography, mathematics, science, and language arts. Still other schools organize curriculum around key topics that develop all the basic skills using the topic as an organizer, indeed, environmental topics are often key organizers for such programs.

Each of these curriculum structures has its pluses and minuses. Different students respond positively or negatively to each. It is both the prerogative and the opportunity for each school system to select the curricular approach which in their opinion assures that students in that school are provided with the knowledge and skills to meet the benchmarks appropriate to their grade levels. The benchmarks are essentially assessment tools to determine the degree of effectiveness of each school to develop and nurture environmental literacy within its student body.

Benchmarks are designed not to tell learners what to think but to assure that they have developed the understandings and skills needed to think, feel, and act in ways that preserve the integrity of the environment to meet not only their immediate physical, social and emotional needs but the needs of generations yet to come. Learners need to be empowered not only to deal with current human/environment interactions and issues, but to perceive and head off potential negative environmental issues in the future.

Getting the Job Done

Teams of educators from each school need to review their curricula and determine the best places to insert the kind of information and skill development that will assure that learners can meet the grade appropriate benchmarks for the learners they guide. It will take some experimenting at each school to assure that their plan is working over several years of effort.

A growing body of instructional materials is available and more is being developed all the time to help teachers and youth leaders develop and foster critical environmental knowledge and skills. Each of these materials makes a contribution to a learner's developing environmental literacy, if the learner is exposed to them.

Teachers have often had limited exposure to environmental understandings and critical and creative thinking skills and environmental decision-making skills in their own educational development. These teachers need involvement in inservice training to give them the basic security to guide younger learners toward environmental literacy. An increasing number of environmental agencies and non-profit groups are prepared to offer just this kind of inservice training. The booklet, *Environmental Education in Massachusetts,* lists many of these groups and exciting locations for environmental education for learners of all ages.

Administrators and school committee members need to formally establish environmental literacy as one of the major goals of their local educational system and work with curriculum coordinators and teachers to see that an effective program is put in place so that graduates at each level are able to meet the appropriate benchmarks. This involves not only the day to day instructional opportunities but opportunities for older students to apply their knowledge in productive community service activities in cooperation with other community agencies and organizations.

Why Do We Need To Do This?

The end product of developing environmental literacy is a citizenry properly informed, properly sensitive to environmental concerns at all levels, and empowered to take responsible action to assure a healthy environment for the present and the future. Environmentally literate and responsible citizens are much more likely to act in ways that prevent ongoing environmental degradation and reduce the need for overly burdensome governmental regulation.

APPENDIX B
Expanded Framework for Earth Systems Education

FRAMEWORK FOR EARTH SYSTEMS EDUCATION

Understanding #1: *Earth is unique, a planet of rare beauty, and great value.*
- The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts.
- Human appreciation of Earth is enhanced by a better understanding of its subsystems.
- Humans manifest their appreciation of Earth through their responsible behavior and stewardship of its subsystems.

Understanding #2: *Human activities, collective and individual, conscious and inadvertent, affect Earth Systems.*
- Earth is vulnerable and its resources are limited and susceptible to overuse or misuse.
- Continued population growth accelerates the depletion of natural resources and destruction of the environment, including other species.
- When considering the use of natural resources, humans first need to rethink their lifestyle, then reduce consumption, then reuse and recycle.
- Byproducts of industrialization pollute the air, land and water and the effects may be global as well as near the source.
- The better we understand Earth, the better we can manage our resources and reduce our impact on the environment worldwide.

Understanding #3: *The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.*
- Biologists, chemists, and physicists, as well as scientists from the Earth and space science disciplines, use a variety of methods in their study of Earth systems.
- Direct observation, simple tools and modern technology are used to create, test, and modify models and theories that represent, explain, and predict changes in the Earth system.
- Historical, descriptive, and empirical studies are important methods of learning about Earth and space.
- Scientific study may lead to technological advances.
- Regardless of sophistication, technology cannot be expected to solve all of our problems.
- The use of technology may have benefits as well as unintended side effects.

Understanding #4: *The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.*
- The subsystems are continuously changing through natural processes and cycles.
- Forces, motions and energy transformations drive the interactions within and between the subsystems.
- The Sun is the major external source of energy that drives most system and subsystem interactions at or near the Earth's surface.
- Each component of the Earth system has characteristic properties, structure and composition, which may be changed by interactions of subsystems.
- Plate tectonics is a theory that explains how internal forces and energy cause continual changes within Earth and on its surface.
- Weathering, erosion and deposition continuously reshape the surface of Earth.
- The presence of life affects the characteristics of other systems.

Understanding #5: *Earth is more than 4 billion years old and its subsystems are continually evolving.*
- Earth's cycles and natural processes take place over time intervals ranging from fractions of seconds to billions of years.
- Materials making up Earth have been recycled many times.
- Fossils provide the evidence that life has evolved interactively with Earth through geologic time.
- Evolution is a theory that explains how life has changed through time.

Understanding # 6: *Earth is a small subsystem of a Solar system within the vast and ancient universe.*
- All material in the universe, including living organisms, appears to be composed of the same elements and to behave according to the same physical principles.
- All bodies in space, including Earth, are influenced by forces acting throughout the solar system and the universe.
- Nine planets, including Earth, revolve around the Sun in nearly circular orbits.
- Earth is a small planet, third from the Sun in the only system of planets definitely known to exist.
- The position and motions of Earth with respect to the Sun and Moon determine seasons, climates, and tidal changes.
- The rotation of Earth on its axis determines day and night.

Understanding #7: *There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.*
- Teachers, scientists and technicians who study Earth are employed by businesses, industries, government agencies, public and private institutions, and as independent contractors.
- Careers in the sciences that study Earth may include sample and data collection in the field and analyses and experiments in the laboratory.
- Scientists from many cultures throughout the world cooperate and collaborate using oral, written, and electronic means of communication.
- Some scientists and technicians who study Earth use their specialized understanding to locate resources or predict changes in Earth systems.
- Many people pursue avocations related to planet Earth processes and materials.

The development of this framework started in 1988 with a conference of educators and scientists and culminated in the Program for Leadership in Earth Systems Education. It is intended for use in the development of integrated science curricula. The framework represents the efforts of some 200 teachers and scientists. Support was received from the National Science Foundation, The Ohio State University and the University of Northern Colorado.

For further information on Earth Systems Education contact the Earth Systems Education Program Office, School of Natural Resources, The Ohio State University, 2021 Coffey Road, Columbus, OH 43210.

APPENDIX C
Sample interview form

ENVIRONMENTAL LITERACY SURVEY

Name:
Date of Graduation:
Position:

1. Do you consider yourself to be environmentally literate?

2. How do you define environmental literacy?

3. How well do you feel prepared to teach others to be environmentally literate?

4. Have you been exposed to any elements of Earth Systems Education including developing a portfolio, cooperative learning methods, etc. in any class at OSU? If so, did you feel that the teaching and assessment methods were helpful?

5. Did you have any outstanding experiences in your natural resources courses?

6. Did you feel that anything was lacking from your education?

7. Any other comments pertaining specifically to our major?

APPENDIX D
Sample ESE course materials

SCHOOL OF NATURAL RESOURCES
THE OHIO STATE UNIVERSITY

Autumn 1995: Special Course Offering for Teachers:

The Great Lake Erie

NAT RES 614, 3 cr G

Wednesdays 4:30-7:30pm
382 Kottman Hall

Lake Erie Protection Fund

The Great Lake Erie, a special offering of Marine and Aquatic Education, uses a cooperative learning format and innovative materials, designed specifically for teachers. Fee waivers are available for a limited number of secondary teachers.

Course goals:

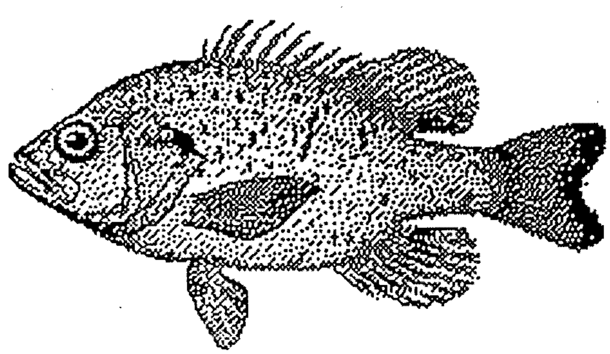
- To provide information about Lake Erie, its values, characteristics and issues, on a level useful for middle and high schools;
- To demonstrate classroom strategies for communicating water-related concepts in the natural and social sciences and the arts;
- To consider the current status of resources of the Great Lakes, and challenges to them;
- To provide information about global environmental issues and their impacts on the Great Lakes; and
- To provide field experiences with the resources of Lake Erie's southern shore.

INSTRUCTOR: Dr. Rosanne Fortner (292-1078 or -9826)

FORMAT: Classes will consist of cooperative learning experiences with laboratory and other activities that illustrate major concepts. Cooperative learning implies full class attendance and participation. An all-day field trip is scheduled for **Saturday, October 14.**

TEXT and RESOURCES: The text is Fortner and Mayer's The Great Lake Erie. A materials fee of $20 covers other course supplies and instructional packets.

EVALUATION: Course grades are based on
- portfolios 50%
- individual project 25%
- active participation 25%
  in all components of class.



SAMPLE COURSE SYLLABUS

1	General Course Information. Constructivist Approaches/Cooperative Learning, Establishing groups, Portfolios, Earth Systems Understanding Activity, Concept map/*Voyage of Life* Activity	Chapter 1
2	Interactions--Atmosphere and Hydrosphere. Characteristics of Weather and Climate (jig-saw), Management of water resources (large group)	Chapters 4 and 11
3	Interactions of atmosphere and all Lake Erie subsystems. More or less large group activity on anticipating change Jig-saw on effects of global change in the Great Lakes Region	Scenarios on global change
4	Interactions--Hydrosphere and Lithosphere. Formation of the Lake Erie Basin jig-saw, Introduction to Great Lakes Resources on the Internet	Chapter 2 Interim Portfolios Due
FT	All day field trip to Lake Erie	Road Log, Chapter 3
PostFT	Debrief field trip: Interactions, Understandings Hydrosphere/Lithosphere interactions: coastal processes and erosion, Jigsaw on coastal erosion and protection devices	Chapter 5
5	The Hydrosphere--Changes within the Lake Erie subsystem. Jigsaw on water movement (storm surges, seiches, density)	Supplemental Readings
6	Interactions--Biosphere and Hydrosphere. Life in Lake Erie (Jigsaw on food webs and pyramids). Wetlands as nurseries and filters, Zebra mussle simulation	Chapters 3 & 13
7	Interactions -- Humans and the Hydrosphere. Shipping in the Great Lakes Region (jigsaw); music of the sea and lakes, Unexpected impacts	Chapters 8 and 9
8	Interactions -- Humans and the Hydrosphere Pollution issues: Nutrients, toxic chemicals, mass media reporting	Supplemental Readings Chapters 14 and 15
9	Interactions -- Humans and the Hydrosphere Additional Environmental Issues	Supplemental Readings
10	Lake Erie Recreation and its Impacts; Jig saw on recreation activties.	Supplemental Readings

PORTFOLIO ELEMENT #9

Lake Erie Environmental Problems

Obtain current information and data on a chemical environmental problem in the Lake Erie Basin.

If possible, report on each of the following:

1. Nature of the contamination.
2. Concentration and allowable standards.
3. Possible sources of the problem.
4. Probable effects on plant and animal (including human) life.
5. Efforts, if any, at containment and/or amelioration.
6. Sources of information you used and problems, if any, you had in finding your information.

You will have difficulty in finding some of the information above. Try the following agencies (phone call) for suggestions as to sources of information; the Ohio EPA, the water division of the United States Geological Survey (here in Columbus), Ohio Sea Grant, Ohio Water Resources Center here on campus. Also check back issues of the Columbus Dispatch and the Cleveland Plain Dealer and other lake shore newspapers. Another source of information, EPA's Toxic Release Inventory on internet, has several databases (www.epa.gov).

Check Agency for Toxic Substances and Disease Registry (http://atsdr1.atsdr.cdc.gov) Search on the name of the chosen chemical.

SCORING RUBRIC

Lake Erie Environmental Problems

Score	Criteria
5	A well designed, creative product that completely addresses the six following components: a. Nature of the contamination -- Fully and correctly describes the nature of the type of contamination, specifically relates to Lake Erie. b. Concentration and allowable standards -- Lists tolerance levels and standards appropriate to the particular contaminant. c. Possible sources of the problem -- Correctly identifies more than one source of the problem. d. Probable effects on plant and animal (including human) life -- Correctly identifies more than one probably effect on plant and/or animal life. e. Efforts, if any, at containment and/or amelioration-- Correctly identifies more than one effort and containment and/or amelioration. f. Sources of information you used and problems, if any, you had in finding your information -- Lists two or more sources of information.
4	A complete answer that fully address the six components listed above
3	Five conditions are complete and correct.
2	Four conditions are complete and correct.
1	Less than four conditions are complete and correct.
0	Completely irrelevant answer OR Blank

Portfolio Element #9
Lake Erie Environmental Problems
Rebecca Vidra

Navigating the Net: Can you make the Chlordane Connections?

ESU's addressed: #2,3,4

Materials: Computer with Internet connection

Objectives: After completing this activity, students will be able to:
- correctly identify the problems/effects associated with chlordane contamination in the Great Lakes region
- draw connections between the sources and sites of contamination
- examine current Great Lakes legislation for chlordane-related standards and clean-up efforts, if any
- feel more comfortable using the Internet

Chlordane is a manufactured chemical used in the United States from 1948 -1988. It is a pesticide that had been used on crops, lawns and gardens, and for termite control. It is a highly toxic persistent chemical that is no longer used in the United States and Canada. However, it is still present in Great Lakes sediments, water, and aquatic organisms. Where did it come from? Is it toxic to humans? How are we exposed to it? What is being done to clean it up? Let's find out the answers to these questions and more by making the Chlordane Connection!

ACTIVITY A: What's the so important about Chlordane anyway?

PROCEDURE:

1. If chlordane was only used on crops, lawns and gardens, and for termite control, how did it get into the Great Lakes? Let's consult ToxFAQs for some answers. Connect to:

http://atsdr1.atsdr.cdc.gov:8080/tfacts31.html

Use this fact sheet to answer these questions:

1. How does chlordane get from the plants to the waters of the Great Lakes?
   Chlordane sticks to soil particles and leaves either by evaporation or by getting washed away by rain. It then builds up in the tissues of birds, mammals, and fish that consume contaminated water.

2. How are humans exposed to chlordane?
   - *eating crops exposed to chemical*
   - *eating fish or shellfish from contaminated water*
   - *breathing air or touching soil contaminated by chlordane*

3. How does chlordane affect humans?
   - *nervous system, digestive system, liver effects*
   - *blood disorders*
   - *may cause cancer*

4. Are there any standards for how much chlordane is safe to consume? Who sets the standards?
- *60 ppb in drinking water (EPA recommendation)*
- *100 ppb in fish (FDA)*
- *0.5mg/m^3 in workplace air (OSHA)*

2. Now that we know the basics of chlordane, let's find out what other effects it may have in the Great Lakes environment? Connect to the Extoxnet:

http://sulaco.oeg.orst.edu:/70/0/ext/extoxnet

After finding the chlordane information section, answer the following questions:

1. What other species may be affected?
- *birds (highly toxic)*
- *aquatic organisms*
- *mammals*
- *bees*
- *earthworms*

2. How do~~es~~ bacteria play a role in chlordane contamination?
Chlordane bioaccumulates in bacteria and in marine and freshwater fish species. The species that consume these bacteria ingest chlordane that build up the higher up on the food chain it goes.

3. Now that we have gathered some facts about the sources and effects of chlordane, let's make a CHLORDANE CONNECTION! Make a flow chart that illustrates where the chemical comes from, how it gets into the Great Lakes, and how humans are exposed. Also include effects on other organisms in the Great Lakes ecosystem. yes

ACTIVITY B: What's being done to get rid of chlordane in the Great Lakes environment?

PROCEDURE:

1. Based on your understanding of chlordane so far, is it easy to remove from the environment? What steps could be done to get rid of it, if any? Remember to consider that soil, water, and air has been contaminated. You may need to connect back to the ToxFAQs for additional information.
Chlordane is a persistent toxic chemical. It stays in soil for 20 years and then is either transported to the air and water. There are no methods for removing chlordane from the air. Dredging of contaminated sediments and containment of soils may be an option but there are high costs associated with this. Because chlordane is found in organisms throughout the food chain, it is impossible to completely remove this chemical from the environment.

2. Many hazardous chemicals are being cleaned-up or are banned in the Great Lakes area. Many policies have been adopted by both the United States and Canada to prevent further contamination of chlordane. Connect to the Great Lakes Information Network to find further information about chlordane containment:

http://www.great-lakes.net:2200/law/lawpolicy.html

Surf around and explore the policies that may contain information about chlordane, Answer the following questions:

1. What laws contain references about chlordane? Can you find a specific reference to target loads for chlordane in Annex 1 of the Great Lakes Water Quality Agreement?
   - *Canada-Ontario Agreement*
   - *Great Lakes Water Quality Agreement (0.06mg/l)*
   - *Great Lakes Water Quality Initiative*
   - *Lakewide Management Plans*

2. Chlordane was banned in 1988. Have you found any references to containment of the chlordane contaminated elements of the environment? If not, explain why.
   Even though many of the Great Lakes policies mention chlordane and have set standards for drinking water and fish consumption, it is nearly impossible to "clean-up" chlordane. Monitoring the aquatic organisms in the lakes is an important way to determine if the chemical has been reduced to safe levels. However, chlordane is a persistent toxic substance and will continue to be a concern.

EXTENSIONS:

1. Efforts to determine if chlordane is carcinogenic have been made by the EPA and the National Cancer Institute. Consult ToxFAQs, the Extoxnet, and the Cancer Network (http://www.isy.liu.se/tegen/NCI_cancerhighlight). Explore the various tests used to determine whether a chemical is carcinogenic, mutagenic, or teratogenic. Why are these test results sometimes hard to interpret?

2. Earthworms are now being used in bioremediation procedures and for fertilization measures. Explore earthworms' effects on the soil and how chlordane affects this process by connecting to Building Your Soil:
http:///www.organic.com/Non.Profits/F2F/Features/earthworm.soil.html

REFERENCES:

The web sites listed in this activity provided the necessary information! A list of additional Toxic Internet sites is included.

INTERNET SITES

Lake Erie Environmental Problems

1. Great Lakes Information Network
   http:/www.great-lakes.net:2200/11/

2. EcoNet
   http://www.igc.apc.org

3. Great Lakes Regional Environmental Information System: GLREIS
   http://epaserver.ciesin.org/

4. US Environmental Protection Agency
   gopher://gopher.epa.gov

5. EnviroGohper (Carnegie-Mellon Student Enviro Gopher Network)
   gopher://envirolink.org

6. Environmental Research Institute of Michigan
   http://www.erim.org/

7. University of Wisconsin Sea Grant Home Page
   http://h2o.seaegrant.wisc.edu/home.html

APPENDIX E
Natural Resources 100 syllabus

NRE 100

ENVIRONMENTAL SCIENCE AND MANAGEMENT

Autumn 1995

Craig B. Davis, Professor
Office Hours: M-W 2 - 3 pm, 322A Kottman Hall
Sandip Chattopadhyay And Ricardo Lopez, Graduate Associates

ECOSYSTEMS

September	20	Introduction; *"Wellsprings"*
	25	Systems and Ecosystems: Ecological Organization
	26	Energy, Climate, Ocean Currents, and Biomes
	27	Energy, Climate, Ocean Currents, and Biomes
October	2	Materials Cycling: General Processes
	3	Biogeochemical Cycles: Carbon and Water
	4	Biogeochemical Cycles: Nitrogen, Phosphorus, Sulfur
	9	EXAM I
	10	Energy Flow in Ecosystems, Productivity and Consumption
	11	Food Chains and Webs, Energy Efficiency and Budgets
	16	Distribution, Tolerance, and Limiting Factors
	17	Populations and Communities: Interactions, Habitat, Niche
	18	Ecosystem Homeostasis: Adaptation, Succession, Evolution
	23	Biological Diversity: What is the Issue? Dr. Gary Mullins
	24	Biological Diversity: *"Remnants of Eden"*
	25	Biological Diversity: Gradients and Stability
	30	EXAM II

ISSUES

	31	Human Population Growth
November	1	Human Population Growth
	6	Sustainable Development
	7	The ATMOSPHERE: Ozone Depletion and Global Warming
	8	*"The Atmosphere"*
	13	The HYDROSPHERE: Clean Water Supplies and Pollution
	14	The BIOSPHERE: Soils, Land Use and Abuse; Deforestation
	15	*"Feed the World"*
	20	EXAM III

SOLUTIONS

	21	Production and Consumption: Environmental Economics
	22	Production and Consumption: Environmental Economics
	27	Environmental Assessment
	28	Conflict Resolution
	29	Environment and Security

Grading:	3 midterm exams	300 points
	10 quizzes	100 points
	1 final exam	200 points

DISCUSSION SECTION SCHEDULE

September	20, 21	*"Wellsprings"* continued Discussion of development/environment issues in South Florida. What are the issues and systems?
	27, 28	Ecosystems, Climate, Global Energy Distribution and the Distribution of Biomes
October	4, 5	Materials cycling, Carbon and Hydrologic Cycles Nitrogen, Phosphorus, and Sulfur Cycles
	11, 12	Energy Flow,Production in Ecosystems. Food Chains and Webs, Efficiency and Budgets
	18, 19	Distribution, Tolerance, and Limiting Factors Populations, Communities, and Homeostasis
	25, 26	Biodiversity
November	1, 2	The Human Population Problem and the Demographic
Transition		
	8, 9	Sustainable Development The atmosphere, Global Warming and Ozone Depletion
	15, 16	Clean Water and Pollution Soils, Food, Land-use and Abuse Deforestation
	29, 30	Economics, Impact Assessment, Conflict and Security Discussion of Final Exam

Suggested Reading Schedule (Botkin & Keller)

September	20	Chs. 1, 2, 28.3
	25	Chs. 3, 6
	26	B-B7 (p.174), Ch. 21
	27	
October	2	Ch. 4
	3	
	4	
	9	EXAM I
	10	Ch. 8
	11	
	16	Ch. 1.3, 7.8, 10.5
	17	Ch. 6, 7
	18	Ch. 9
	23	Ch. 7, 12
	24	
	25	
	30	EXAM II
	31	Ch. 1.2, 5
November	1	
	6	
November	7	Ch. 21, 24
	8	Ch. 22
	13	Ch. 19, 20
	14	Ch. 11
	15	Ch. 10
	20	EXAM III
	21	Ch. 25, 30
	22	
	27	Ch. 29
	28	
	29	

APPENDIX F
Natural Resources 606 syllabus

NR606 Natural Resources Management

Instructor: **Dr. Robert W. Douglass**
Instruction Team: **Mr. Steven Richards, Computer Laboratory T.A.**
Ms. Valerie Winland, T.A.
Ms. Gayle Y. Sylvester, Secy. - Tele.: 688-3135
Room 469C, Kottman Hall
Telephone: 292-9785 office
436-0836 answering machine

Course Description

This nation has 2.1 billion acres of land and associated waters to be used, utilized, and protected for the public welfare. The management of nation's natural resources, whether publicly or privately owned, is a critical responsibility. Preparation of students for the management of natural resources both in this country and throughout the world is a major concern of this School. This course provides the ›portunity for students interested in natural resource management to learn how to integrate their .echnical knowledge with the social and institutional constraints that will influence their actions in their chosen management professions.

Course Purpose

Management implies decision and manipulation. It is the judicious application of knowledge to accomplish a result. This course will serve to give students an understanding of the management process and the ways that their technical knowledge fits into the process.

Course Objectives

1. Students in this course will learn the ways that decisions concerning the use of nation's natural resource base are made and how they are implemented and monitored.

2. Students will gain an understanding of how their technical and professional knowledge can be applied in the larger picture of multiple resources management. The interactions and impacts of those applications will be learned.

3. Students will learn about the various professional organizations and literature that influence and inform the natural resource management effort.

General Description

NR606, Natural Resource Management, is the "Capstone Course" for all Natural Resources undergraduate students. As such, NR606 is presented as an applied course where the senior Natural Resources students have already completed the required courses within their major specializations. Therefore, this course will ask you to apply those technical and policy theories that you have studied and learned during your years as undergraduate students. Each of you brings to this class the special skills and knowledge that you came to the School of Natural Resources to acquire. This is your chance to put that knowledge to work in solving a simple management problem within the constraints of today's natural resources work place.

You will be asked to solve a problem within the constraints of a federal bureaucracy. Parts of your being able to succeed in your chosen profession depends upon your ability to fit your knowledge into the political and regulatory situation that exists. Private industry operates under constraints that are just as limiting, guiding, frustrating, leading, and all the other adjectives associated with "Red Tape". Actually, our example uses a federal bureaucracy which, believe it or not, is simpler than the industrial bureaucracy.

This course, as with other upper division courses, requires interest and prior preparation by the student. The instructor serves as a director of discussion and not as the sole authority on the subject. The faculty team will serve to help you move through the process of solving the problem. However, that team is not to serve as the technical experts in any discipline. Each of you serve as your team's authority on the subject of your major specialization. Student preparation for each class is mandatory. **Attendance at every class is mandatory**. Please contact the instructor when you know that you can not attend a class. Papers will not be accepted after their due dates except in special cases.

The instructor encourages individual discussions on the course work. Please make an appointment. This can be done by contacting Gayle Sylvester at 688-3135.

Papers and Reports

The class will be divided into Interdisciplinary Teams (IDT) by the instructors. Students will be assigned to IDT's so as to create the best discipline mix possible with the students enrolled. Your work situation will approximate that which you will encounter when you work for a resource managing company or public agency. That is, you will be expected to produce professionally completed products from your team even though the team members might not be your best friends.

Grades will be earned by the IDT's -- not by the individual students on the team. Quizzes and class participation are exceptions to the team grading concept. Those grades will be awarded for individual effort and correctness. **ALL TEAM MEMBERS ARE EXPECTED TO PARTICIPATE IN PREPARATION AND PRESENTATION OF THE REPORTS.**